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AUTHOR Watt, Molly L.; Watt, Daniel H.

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ABSTRACT

This paper describes a series of collaborative research seminars designed to allow classroom teachers to observe and assess critical aspects of Logo learning in their own classrooms. Based on structured interviews with participating teachers, the workshops are designed to support classroom teachers in observing their own students, collecting data about their work, and assessing their learning of Logo. Printouts of student Logo programs and a critical aspects checklist provide data for group discussion. The case study approach is used to help teachers in presenting data and research questions about a student's work. It is noted that an important outcome of the research seminars involves documenting the professional development of participating teachers. Personal experiences of one participant are included, as are samples of students' Logo work, a student data template, and the critical aspects checklist. (21 references) (DB)

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Education Development Center, Inc.
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Teachers as Collaborative Researchers: Professional Development Through Assessing Logo Learning

Molly L. Watt
and
Daniel H. Watt

September 1988

edc

55 Chapel Street
Newton, MA 02160
(617) 969-7100

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Teachers as Collaborative Researchers: Professional Development Through Assessing Logo Learning

To be presented at the National Educational Computing Conference
Dallas, Texas -- June 1988

Molly L. Watt and Daniel H. Watt,
Senior Associates
Education Development Center
Center for Learning Technology
55 Chapel Street
Newton Massachusetts 02160
(617) 969-7100

Abstract

This paper describes a series of collaborative research seminars designed to allow classroom teachers to observe and assess critical aspects of Logo learning in their own classrooms. We define critical aspects of Logo to be those concepts drawn from the domains of computer science, mathematical thinking and problem-solving which are essential for students to use and understand if they are to gain maximum benefit from their Logo learning experiences. This paper describes the approaches we developed to support classroom teachers in observing their own students, collecting data about their work, and assessing their learning of these aspects of Logo. We also describe our approach to assessing the professional development of teachers who participated with us as collaborative researchers.

This work was supported by the National Science Foundation as part of **Exploratory Research on Critical Aspects of Logo Learning**, grant number MDR 865 1600. We would also like to acknowledge the contributions of research consultants Roy Pea of New York University and Jan Hawkins of Bank Street College of Education, our Research Assistant, Joan Funk and Administrative Assistant, Gerry Sills of Education Development Center, and collaborating teacher researchers, Elizabeth Berrner, David Crump, Diana Freedman, Doreen Kelly, Robert Kondel, Jane Manzelli, Mary Miller-Teehan, Pasquale Puleo and Kitsy Rothermel. Any ideas, opinions, findings and conclusions expressed in this paper are those of the authors and do not neccessarily reflect the views of the National Science Foundation or of any of our collaborators.

I. INTRODUCTION AND BACKGROUND

Our project started with questions by teachers and findings from research which indicate that the educational potential of Logo is not yet fully realized in classrooms. We are often told, "Logo isn't working," or "Students aren't learning important mathematics and computer science through exploration and discovery." (See, for example: Pea, et. al. 1987; Kurland et. al. 1985; Watt, D. 1982; Moursund, 1983; Leron, 1985a,1985b) These opinions, distressing as they sound, match some of our own observations while teaching Logo to both children and teachers. The learning challenges our own students encounter demonstrate the types of difficulties experienced by many Logo learners.

As we compared these observations about student learning with the powerful ideas embedded into the Logo language itself by its developers (Papert, 1980; Watt D. 1982; Watt M. 1982; Watt and Watt, 1986), we began to develop the concept of critical aspects of Logo learning, aspects of Logo which when understood and used by a Logo programmer allow that person to use Logo powerfully. And in our experience, the most powerful uses of Logo involve project-oriented work of the learner's own choosing which leads to the learning of important mathematical and computer science ideas while in the process of carrying out the project. Critical aspects, therefore, can serve as a framework by which a teacher can assess and guide students as they work on their own projects.

For the past year we have been working with teachers as collaborative researchers to use the concept of critical aspects of Logo to identify and describe important Logo learning in their own classrooms. It was our expectation that teachers who participated with us in this work would be able to document and demonstrate the value of the Logo learning in their own classrooms. To support this process we conducted an ogoing series of seminars to involve the teachers in a community of colleagues with a shared purpose.

Part of our model for collaborative research seminars came from our own experiences as teachers and researchers. Our extensive work with the development of teacher centers encouraged us to value teachers' professionalism. We modeled some of our seminar structure on the Children's Thinking (Research) Seminars developed and led by Bill Hull and Sara Hull (Hull,

1979; Watt. M, 1979). Some of our ideas about supporting teacher investigations were learned from Evans, Bamberger and Duckworth (Evans, Stubbs, Duckworth, and Davis, 1981; Bamberger, Duckworth, and Lampert, 1981; Duckworth, 1986). In our research and development work with Patricia Carini at The Prospect Archive of Children's Work and Research Center, North Bennington, Vermont, we participated in developing procedures for teachers to support each others' classroom action research projects (Carini, 1979). Our participation in The North Dakota Study Group on Evaluation gives us many models of qualitative research, observation and documentation processes teachers can carry out in their own classrooms.

This collaborative research project embraces many of our concerns for educational reform. We desire to support teachers in developing a growing sense of their own professionalism. And we desire to support both teachers and students in using Logo in the powerful ways and for the powerful purposes envisioned by its developers (Papert, 1980). In this paper we focus on the processes and experiences of the teacher research seminars and on the professional development of participating teachers. Issues related to critical aspects of Logo, and student learning will be discussed elsewhere.

II. THE RESEARCH SEMINARS

Our design for a teacher research seminar was based on prior experience with collaborative research, and on a broad survey of research on professional development of practicing teachers. Of particular importance to us is the research on Stages of Concern, and the Concerns-Based Adoption Model (Hall, et. al, 1973; Loucks and Hall, 1979). The central finding of this work is that teachers engaged in implementing a classroom innovation go through a predictable development in their concerns about and attitudes towards that innovation. Teacher education efforts that take these concerns into account, provide opportunities for teachers to express their concerns, and adapt the content of training sessions, workshops or seminars to fit the concerns of the teachers involved, have a much better chance of changing educational practice than activities which are not designed in this way.

Other research findings which informed our seminar design showed that teachers are more likely to use new content and teaching approaches in their classroom if they see specific instructional approaches modeled in training sessions; have time to practice the approaches

modeled, and adapt the materials to their own situations; learn substantially more content than they plan to teach, and engage in learning experiences at their own level, while preparing to use a new approach with children; have opportunities to reflect on their own experiences, talk things over with colleagues, and experience support over time; and are recognized for their own areas of expertise.

We began our seminar series with a group of twelve teacher/researchers: a team of two teachers and a computer coordinator from each of four Boston area cities and towns. We met for eleven sessions, three all-day meetings and eight after-school meetings from 4:00 - 6:30 PM. Lunches were provided for the all-day sessions, and the teachers and project staff took turns contributing refreshments for the after-school meetings.

Each session began with a review and revision of the daily agenda, and ended with a four-question evaluation form. Each session was recorded, and parts of the recordings were transcribed for inclusion in the Notes and Commentary, compiled for each session by the project staff.

Activities varied from session to session. For example, the agenda for Session #3 (February 25, 1987) shows that the group started with refreshments; broke into triads to discuss "What do we look for when we observe students learning with Logo?"; reported back to the larger group; then broke into school-district teams to choose the two particular students whose work each teacher would follow for the rest of the year. The agenda for Session #6 (April 8, 1987) shows that the group started with refreshments; broke into two research groups focussing on examples of student Logo work brought in by teachers, each with a chairperson and a presenter; went on to share details about conference participation and presentation planning; and ended with a mathematical challenge for the researchers to solve in Logo.

The research seminars evolved through four distinct phases over the course of eleven sessions:

1. Learning to see: The first few weeks of the project were devoted to finding out what we were looking for and developing a common language to describe it.
2. Giving more structure to the research: These sessions were devoted to identifying and refining specific research questions, choosing students to follow, looking at the kinds of data available, and structuring the data collection and observations.
3. Looking at the patterns in the data: These sessions were devoted to attempting to understand what we were learning, and reflecting on our process of gathering data.

4. Writing project reports: At the end of the seminar series, the teachers wrote individual reports on their classroom research. Throughout the project, staff members wrote ongoing Notes and Commentary and progress reports in preparation for writing research reports.

We maintained a circulating library of shared resources: research reports, district Logo curriculum guides, Logo activity books and related magazines for participants to borrow. Most participants took advantage of this. Two members borrowed Logo research reports and most borrowed materials and books with Logo activities. We felt constrained by time limitations and did not get an annotated bibliography written for this group. We plan to continue the practice of sharing resources and expect to find more ways of putting relevant materials into each person's hands in future seminars.

The process we developed requires a group of committed participants, and several designated roles: a session leader; a note-taker; a Notes and Commentary writer; someone to copy disks and data brought in by participants for the group; someone to record the sessions; a librarian and food providers. These roles can be rotated or reassigned periodically.

We consider the teacher research seminar to be a generic form. The specific materials and approaches we developed, in this case the critical aspects of Logo, could be replaced by a different research focus.

III. OBSERVATION AND DATA COLLECTION TECHNIQUES

1. Structured Interviews:

Each of the teacher/researchers in our seminar, besides being an experienced classroom teacher, had a minimum of two years experience teaching with Logo. Before beginning the seminar process, we conducted structured interviews with participants at their school sites. The interview gave us an opportunity to visit each classroom, meet with school administrators and understand the contexts in which our colleagues were working. It also provided a key source of data for understanding any professional development that might occur during the course of the seminars (see Section IV below). Finally, it allowed us to understand how the seminar participants thought about Logo, how they taught it, what their goals and objectives were, what

they thought their students were learning, and how they knew whether their students were learning it.

The interview we used was designed by research consultants Roy Pea and Jan Hawkins, along with the project staff, to provide background information about each teacher's professional background, Logo experience, educational ideas and values, classroom situation, and Logo teaching space. It was designed to evoke a description about their Logo teaching practice by asking, for example: Describe your Logo curriculum. What content do you want your students to learn this year (cognitive objectives)? What is it important for your students to be able to do (performance objectives)? What other types of behavior or attitude changes do you hope for among your students as a result of Logo (Social objectives)? The interview went on to ask about teaching methods, where Logo fit into the day's schedule, the amount of Logo time spent both on and off computer and how else Logo work was structured. The section on teaching practices ended with questions asking about the teaching results: what students were learning, what discrepancies or surprises they had noticed between what they expected to happen and what actually had happened, differences among learners and any specific problems at specific stages of Logo learning.

The second section of the interview schedule asked about the Professional Development of the teacher/researcher. We asked how the participant began to use Logo, what workshops or courses had been taken, how they assesed their own knowledge of Logo, and what goals they had for their own continued learning of Logo. We asked how each teacher reflected on practice: how they set and monitored personal goals for teaching, and how they recorded plans, projects, ideas and problem areas. We also asked, "How do you improve and debug your own teaching?" We asked about their individual beliefs about Logo's importance and benefits for their students, how children learn it best and how they assess and monitor student knowledge and progress.

The third section asked questions about accountability and reporting practices with regard to their Logo teaching. The fourth section asked about their past experience with research and their expectations, hopes and dreams for this exploratory research project.

2. Using Printouts of Student Logo Programs as Data:

The fifth section of the interview was almost an afterthought. We added it to the interview the

day the principal investigators started the classroom visits and teacher interviews. At the end of each interview we asked each teacher to give us a printout of a Logo program by one student and tell us something about the program and why they chose to show it to us. We intended to use the printout to start the process of documentating and assessing Logo learning. We had assumed that printing out examples of student procedures and pictures would be part of a Logo teacher's usual practice. We were surprised that nine of our twelve collaborative researchers required technical assistance to print examples of student work. None of the researchers used printouts regularly to build archives of student work, or to assess learning in order to plan teaching interventions. Nor did they use them as models for their students to study. In fact several of the teachers reported that they rarely looked at a student's programming code at all unless a student asked them for debugging help.

After we demonstrated how to print Logo procedures and graphics, we continued to work with teachers to define an appropriate form for presenting eaxmples of student work to make them understandable for analysis of student learning. We developed a template indicating where to put the identification labels, dates and margins and a printout of the screen (see Figure 1). The procedures are printed out in order, with a procedure tree mapping the order in which each procedure and subprocedure is called. Then we helped participants learn how to do each of these steps. Later in the project, we developed some Logo tool procedures which generate procedure trees automatically and printout procedures in the correct calling order. (These Logo tools were adapted from models created by Richard Carter of Lesley College).

3. What can printouts of students' procedures tell us about what they know?

We used student projects as data for a group process in assessing student work. Our goal was to describe the Logo, mathematics and computer science ideas that the student used in a particular project. Eventually we evolved Four Questions for looking at student examples. First we asked, "What does this student know?" Then, "What is not known by this student?" Next, "What can you suggest to this student to solve his problem - in his way?" And finally, "Based on what this student has already done, what might he be ready to learn next?"

Sometimes we looked at copies of a student's printout and ran the computer program. Some times we actually rearranged and added code to the program in an attempt to improve our understanding about how the student was thinking about a project, and to develop strategies for

coaching that student on debugging or programming difficulties.

This process proved to be extremely fruitful for assessing the Logo knowledge a student was using. It often became the basis for diagnostic teaching using an emerging curriculum. When we studied several printouts of examples from the same student produced over a span of time, it was fairly straightforward to document increased Logo, mathematical and computer science knowledge. With practice, teachers could identify development and describe it in specific terms. For example, see Figure 2, showing two examples of the work of Kathy, a fourth grader, collected several weeks apart.

4. Critical Aspects and Teacher Interviews:

We used our (evolving) critical aspects checklist as a reference for studying printouts of student work (see Figure 3). To use the list effectively, we found it necessary to focus on one or two clusters of critical aspects at a time. The whole list was just too large to use as a clear focus for observation.

We experimented, and eventually found a way to use the critical aspects checklist as a structure for an interview. This gave teacher/researchers another way to access their own knowledge about what a particular student knew about Logo. (But we had to practice the process several times before we learned to use it effectively -- one teacher/researcher described a seminar demonstration of a preliminary attempt as "deadly"!) An example of the way we might use the interview is to ask the teacher what the student knows about using procedures. By looking at student examples we saw that that Sally and Pattie, whose keystrokes were stored in dribble files, probably did not know how to define procedures (see Figure 4). Kathy's show she was learning to combine steps and eventually define her projects in smaller conceptual pieces (see Figure 2). Whereas Heather shows us in her diagrams a fairly sophisticated way of using a superprocedure as a planning device (see Figure 5).

We developed and used this interview form towards the end of our project, and anticipate that teacher/researchers will be able to use it to support each other in future seminars. We expect that this process can also be used by experienced teachers, working with colleagues in their own schools, to structure their assessments of student knowledge.

5. Group Discussions and Notes and Commentary:

In our research meetings we used discussions and group conversations as another way to support teacher/researchers in gaining access to their own knowledge and observations. We audiotaped most group discussions as part of the project documentation, and these tapes were used to write a set of Notes and Commentary on each meeting. The writer of Notes and Commentary reflected on some of the key ideas, insights and concerns raised in discussions and often quoted a participant's exact words or program examples (Watt, M. 1979; Carini, 1979; and Schon, 1983). Participants reading the Notes and Commentary found that it provided another opportunity to reflect on their experiences and to synthesize their own knowledge.

We also used the tapes of one meeting to help set the agenda for the next one. In this way we modeled some diagnostic teaching strategies within the research seminars themselves, and were able to work closely with the participants to support individual and group development and concerns.

6. Seminar evaluation Questions:

Another form of seminar assessment data came from the responses to the four evaluation questions we asked each person to answer at the end of every session:

1. Question #1: What was the most important learning insight you had at today's meeting?

2. Question #2: What were you most perplexed by or concerned about at today's meeting?

3. Question #3: What would you like to talk about - or do - in future research meetings?

4. Question #4: What help, collaboration, or resources would support your continued work?

Answers to these questions were collated into a group response sheet and copied for everyone.

7. A case-study process to support research:

Another specific technique we developed is a case-study process to facilitate a

teacher/researcher in presenting data and research questions about a student's Logo work. Its design is based on previous work by Molly Watt (and others) while she was a Program Associate at the Prospect Archive and Research Center, North Bennington, Vermont, with Patricia Carini. The process was formalized, with specific roles and procedures, so that it could be used as a model, first for teacher/researchers in the seminar, and later for teachers to use with students in the classroom (Carini, 1979 and Martin, 1987).

Here's how this case-study approach works: Suppose a teacher has brought in several examples of a student's work to assess and wonders about the logic in the way the student is naming procedures. The procedure names seem miscellaneous to her and it is the teacher's impression that this student is often confused about how to find his project because he can't remember its most recent name or the names of its component parts. She wants the group to look with her at the student's work, trying to make sense of whatever logic she can identify and then have several strategies in mind for supporting the student in finding a scheme which would serve the student better.

These concerns lead to a focussing question which the teacher gives to the chairperson. (If the teacher does not have a clear focussing question it is the chairperson's responsibility to support her in finding one before meeting with the group.) The chair examines the data and makes sure that there is a computer for demonstration, if needed, or that printouts or journal notes are reproduced for the group to easily see. She then calls the meeting together, introduces the teacher, any description needed, the focusing question, the data and any constraints.

The teacher/presenter then describes the data, as specifically as possible, avoiding judgemental statements, and allowing the meaning to emerge from the description, the process and the data. The chair may invite the group to add descriptions of what they notice, without seeking consensus or discussing interpretations. The chair facilatates, takes notes and periodically summarizes. Then the chair asks for responses or suggestions about the focussing question. The group members offer specific insights. The chair writes down each suggestion without discussion or evaluation or questions. The presenter listens without responding to or evaluating the ideas offered.

After the group has completed supporting the presenter's observations, and responded to her focussing question, the members have a brief discussion of what was interesting and what they

learned from the process about their own work and students.

Later it is the chair's task to write up notes about the meeting for everyone.

The development of this process was begun during our research seminars, and completed during the Assessing Logo Learning mini-course taught by Molly Watt and Stephen Shuller at The Logo Institute, August, 1987. In future research seminars, notes on research presentations will be integrated into the seminar process.

8. Individual Classroom Research Projects:

The teacher/researchers focussed their classroom research around their own pedagogical questions. Some examples are:

- How can I develop creative challenges to help students learn to use variables in Logo projects, which fall within my mathematics curriculum and the abilities of my students?

- How can we get more students to use meaningful names for their subprocedures?

- How can I get students to use superprocedures in a top-down programming style?

Questions about teaching strategies led to specific research questions, that could be used to determine the types of data that each teacher wanted to collect about what their students were learning. The teachers reformulated these questions several times, trying to find the right match between what they wanted to find out, and the data they were able to collect naturally as part of their on-going work.

Another way that teachers focussed their research was by choosing two students to observe, closely documenting their Logo learning. We asked them to choose one student about whom there was some particular aspect that interested them professionally. Then they chose a second student of the other sex, and with a different level of Logo expertise. (Our general categories were "struggling," "average," and "facile" Logo user.)

IV. PROFESSIONAL DEVELOPMENT

An important outcome of our research involves documenting the professional development of the teachers who participated with us as collaborative researchers. We have articulated a set of criteria for determining whether professional development occurred among participants in our research seminars:

- Do teachers indicate better understanding and articulation of what their students are learning?
- Are there any indications of changes in classroom practice during the process of this research project?
- Are there indications of willingness to share work with other professionals through writing and conference presentations?

The data we have collected, as a basis for analysis of professional development, include:

- pre/post structured interviews, described above
- pre/post Stages of Concern Questionnaires
- session-by-session materials: teachers' journal entries; teachers' examples of student work; teacher's research questions - original and revised; participants' evaluation forms for each session
- written research reports by teachers
- tape recordings of oral reports by teachers
- letters from participants about the project
- project information forms indicating future plans of participants
- information about presentations by participants at conferences and within their own districts

Preliminary review of our data with regard to the above criteria gives us reason to believe that a full analysis will demonstrate significant professional development on the part of participating teachers. We expect to complete the analysis by March 1988. The two illustrations that follow show what we consider to be indications of professional development.

The first example from our structured interviews with David Crump, a fourth grade teacher, demonstrates a change in his articulation of his approach to assessing student learning:

February Interview:

Q 25: What is your belief about how to assess what students know and monitor their progress?
A: My own experience in that area is based upon what students show me, and explain what they do. I have to say that I do get insight into how children are thinking when they ask me questions about how to do certain things, or to see that they at least know that they need to know something more to do what they want to do.

June Interview:

Q. 25: What is your belief about how to assess what students know and monitor their progress?
A: Over time. Seeing changes. And documenting those changes. And actually holding it up to some measure, whether that be the critical aspects or some other criteria. Seeing the physical evidence that students have been able to do some things. They've made some progress.
Q: In order to do this, you need to keep track of that information, because otherwise you can't compare it.
A: Yes. And it doesn't have to be every project or every time. It can be at the beginning of the year, in each of the next two quarters, and at the end of the year.

The second example from the same teacher is an excerpt from his final research report and indicates a change in his understanding about Logo's importance in the elementary school curriculum as a vehicle for students learning about mathematics, problem solving, programming and their own thinking.

Excerpt from "A Summary of the Classroom Research Conducted During the Logo Collaborative Research Project" by David Crump, June, 1987:

Finally I will reflect upon some differences in my way of thinking about Logo that resulted from my participation in the LCRP. Over the past five years I have been involved in either learning about or teaching Logo. I honestly felt that I knew all I ever needed to know about Logo in order to very successfully teach Logo in my classroom as delineated by our school curriculum.

I recently became one of those educators who began to question why so much emphasis was being placed on the teaching and learning of Logo in elementary schools. I wondered if the benefits derived from children using Logo justified the time, effort and money invested in having it taught. Questions also surfaced in my mind concerning my own level of understanding of and

knowledge about Logo. I began to feel that if I was more aware of some of the finer points of Logo, and understood better some of Logo's more powerful features, perhaps I might begin to see things in Logo that I'd been missing. When the opportunity became available to me to participate in the LCRP, I jumped at the chance, hoping to resolve some of the issues about Logo that concerned me.

The intensive training in the critical aspects of Logo learning that was a component of the LCRP seminars by far outweighs and outdistances anything I learned about Logo in workshops or courses. The training seminars constituted not only a redefining of what is important about Logo, but also a refining of Logo learning that I believe will enable me to be a much more effective teacher of Logo.

What I learned about recognizing and understanding the critical aspects of Logo learning, coupled with teaching strategies, methods of oservation, as well as other material developed from this project related to methods of evaluating and enhancing Logo learning of students, is of greater value to me, and should be a model made available for other teachers of Logo. I believe that knowledge of and training in the critical aspects of Logo learning can provide a framework for curriculum developers who may need to reformat their present Logo curriculum, and develop new activities that provide the proper Logo experiences for students, so that they do progress in their learning and understanding of Logo.

I am now ready to justify in my own mind why the teaching of Logo is important. If taught the right way, students learn to think both logically and creatively. Not only do they have the opportunity to learn about Math, problem solving, and programming, but more importantly they begin to learn about their own thinking.

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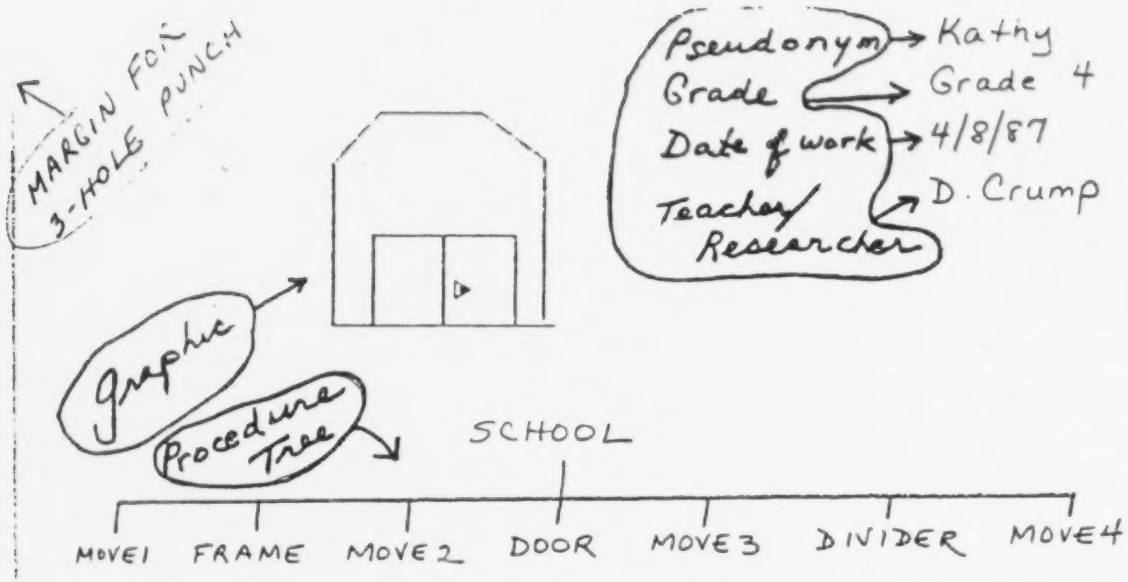


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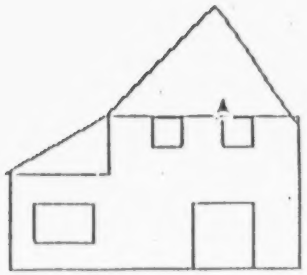
 FD 50
END

TO MOVE4
 PU
 BK 30
 RT 90
 FD 5
 PD
END
```

Procedures in order

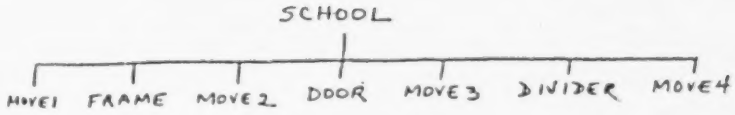
FIGURE 1: Student Data Template

Kathy
Grade 4
Late March, 1987



```
TO HOUSE.6
 PU
 BK 30
 BK 20
 RT 90
 FD 30
 FD 20
 LT 90
 FD
 FD 50
 FD 10
 FD 20
 LT 90
 FD 65
 FD 30
 LT 90
 FD 30
 RT 90
 FD 30
 FD 20
 LT 90
 FD 30
 FD 10
 FD 5
 FD 4
 LT 90
 FD 56
 FD 56
 FD 20
 FD 10
 FD 3
 PU
 LT 90
 FD 56
 FD 30
 BK 5
 BK 4
 BK 3
 LT 45
 RT 5
 RT 3
 RT 4
 FD
 FD 20
 FD 30
 FD 20
 FD 5
 LT 103
 FD 80
 RT 15
 FD 60
 PU
 RT 121
 BK 15
 RT 90
 FD 15
 FD
REPEAT 2 [FD 30 RT 90 FD 20 RT 90]
 PU
 FD 80
 FD
REPEAT 2 [FD 20 RT 90 FD 33 RT 90]
```

Kathy
Grade 4
Early April 1987



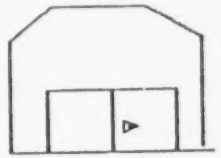

```
 PU
 LT 90
 FD 20
 FD 20
 FD 4
 LT 90
 FD 5
 FD
 FD 15
 LT 90
 FD 15
 LT 90
 FD 15
 LT 90
 FD 15
 RT 90
 PU
 FD 20
 FD 15
 BK 15
 FD
 FD 15
 RT 90
 FD 15
 RT 90
 FD 15
 RT 90
 FD 15
 RT 90
 FD 15
END
```

```
TO SCHOOL
 MOVE1
 FRAME
 MOVE2
 DOOR
 MOVE3
 DIVIDER
 MOVE4
END

TO MOVE1
 PU
 BK 60
 RT 90
 FD 50
 LT 90
 FD
END

TO FRAME
 FD 90
 LT 50
 FD 40
 LT 40
 FD 50
 LT 50
 FD 37
 LT 40
 FD 90
 LT 90
 FD 110
END

TO MOVE2
 PU
 LT 180
 FD 20
 RT 90
END
```



```
TO DOOR
 PD
 FD 50
 LT 90
 FD 70
 LT 90
 FD 50
END

TO MOVE3
 PU
 LT 90
 FD 35
 LT 90
 FD
END

TO DIVIDER
 FD 50
END

TO MOVE4
 PU
 BK 30
 RT 90
 FD 5
 FD
END
```


FIGURE 2: Kathy's (grade 4) work compared:

shows more sophistication in April 1987 than it did in March.

Critical Aspects of Logo Learning – Checklist and Notepage

I. Procedures and Subprocedures
_____ A - Pre-procedures
_____ B - REPEAT
_____ C - Undifferentiated procedures
_____ D - Use of subprocedures
_____ E - Structured programming
_____ F - Modular programming styles
_____ G - Procedures using recursion

II - Procedures with Variables
_____ A - Pre-variables
_____ B - Procedures with simple inputs
_____ C - Procedures with proportional inputs
_____ D - Procedures with multiple inputs
_____ E - Using inputs with Subprocedures
_____ F - Procedures that reverse recursion, incrementing variables and conditionals.
_____ G - Using global variables (MAKE).

III - Mathematics of turtle geometry - using 360 degrees
_____ A - 360 degrees as a complete rotation.
_____ B - Using special angles (factors of 360 and their multiples): 90, 180, 30, 45, 60
—
_____ C - Using angle x no. of sides = 360.
_____ D - Using the total turtle trip in constructing figures

IV - Mathematics of Turtle Geometry - other geometric ideas
_____ A - Playing turtle
_____ B - Distinguishing moves and turns
_____ C - Using inverses right/left, forward/back
_____ D - Using right/left symmetry
_____ E - Using similarity
_____ F - Using transformational geometry
_____ G - Using and understanding wrapping

V - Learning Through Exploration
_____ A - Keeping track of sequences of commands
_____ B - Taking advantage of accidents
_____ C - Looking for patterns
_____ D - Testing hunches
_____ E - Testing the limits of the system
_____ F - Making hypotheses

VI - Debugging
_____ A - Using error messages
_____ B - Recognizing familiar bugs
_____ C - Playing turtle
_____ D - Describing the bug
_____ E - Isolating the bug
_____ F - Using computer debugging tools: (PRINT, HEADING, SHOWTURTLE, TRACE
—)
_____ G - Accepts bugs and debugging as part of the process
_____ H - Knows explicit strategies for debugging help: (simplify, look for a similar example, ask a friend, —)

VII - Planning a Project
_____ A - Setting appropriate goals
_____ B - Drawing pictures as planning aids
_____ C - Dividing problem into parts
_____ D - Simplifying, setting intermediate goals, revising a plan
_____ E - Elaborating a plan
_____ F - Using a superprocedure in planning
_____ G - Using a procedure tree in planning

VIII - Managing Workspace and Files
_____ A - Saving procedures on disk in an undifferentiated workspace
_____ B - Using commands to get information: (POTS, PRINTOUT or PO, CATALOG.)
_____ C - Using record-keeping strategies to keep track of work: naming files by date of project; recording procedure names and file names in a journal. —
_____ D - Saving clearly differentiated files for separate projects, special tools. —
_____ E - Cleaning up workspace and files: erasing unneeded procedures and files

Figure 3: A draft checklist of critical aspects of Logo Learning. By making checkmarks at different places on the line, from left to right, teachers can indicate levels of student mastery, from "has barely heard of this idea," to "has mastered this well enough to teach it to others." The right hnad side of the page is used for other comments.

```
?REPEAT 4[15 RT 90]
I DON'T KNOW WHAT TO DO WITH :S
?
?
?
?
?
?REPEAT 4[FD 50 RT 90].
?SETPC 3
?PU
?FS
?SETPC 0
 SETPAL 0
?SETPAL 1.
?TS
?MS
?FS
?TS
?MS
?SETPC 3
?REPEAT 4[FD 50 RT 90]
?PD
?REPEAT 4[FD 50 RT 90]
?SETPAL 0
?SETPC 1
?REPEAT 4[FD 100 RT 90].
?SETPC 2
?REPEAT 4[FD 60 RT 90]
?SETPAL 1
?SETPC 1
?SETPAL 0
?REPEAT 3[FD 25 RT 120
?FD 30
?SETPC 2
?REPEAT 3[FD 30 RT 120]
?SETPAL 1
?SETPAL 0
 FD 20
?FD 20
?REPEAT 20[FD 90 RT 93]
```

Figure 4: Sally and Pattie's dribble file (grade 5): **a keystroke-by-keystroke record of their work shows that they are not using procedures at this time.**

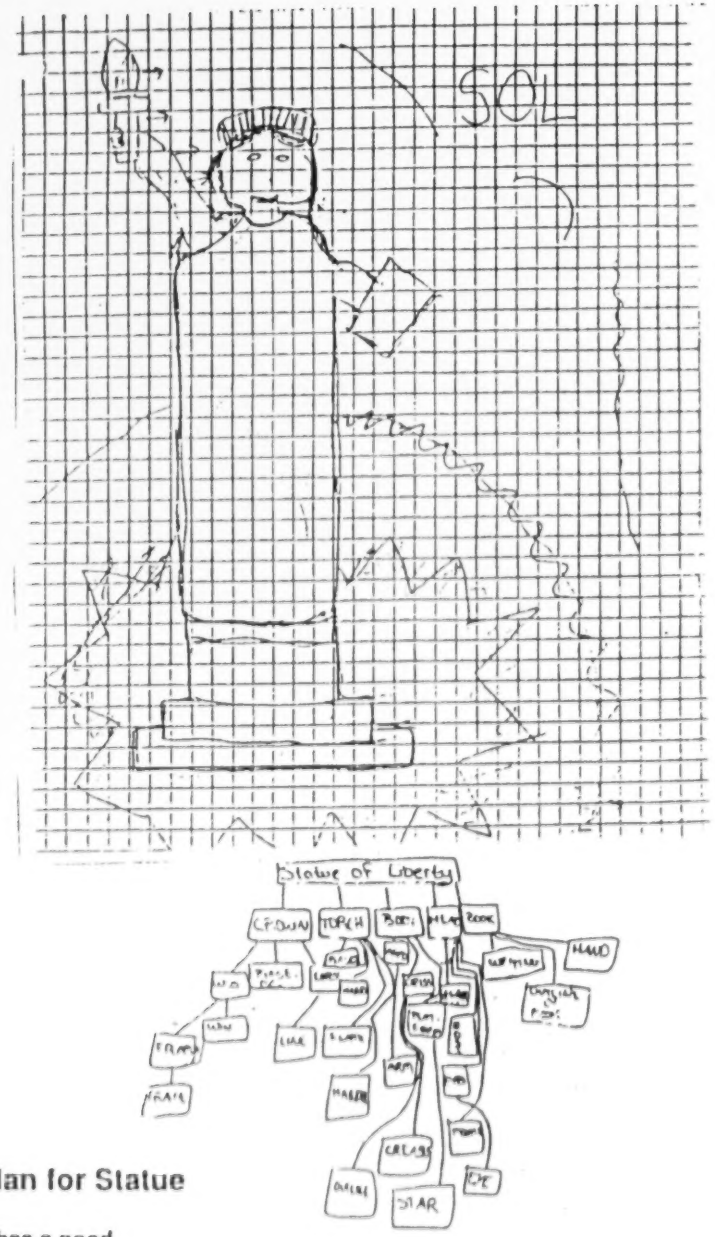


Figure 5: Heather's (grade 6) plan for Statue of Liberty project: **shows that she has a good understanding of subprocedures, and uses a superprocedure as a planning device.**